

Mole Conversions Worksheet

There are three mole equalities. They are:

$$1 \text{ mol} = 6.02 \times 10^{23} \text{ particles}$$

$$1 \text{ mol} = \text{g-formula-mass (periodic table)}$$

$$1 \text{ mol} = 22.4 \text{ L for a gas at STP}$$

Each equality can be written as a set of two conversion factors. They are:

$$\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ particles}} \right) \quad \left(\frac{6.02 \times 10^{23} \text{ particles}}{1 \text{ mole}} \right)$$

$$\left(\frac{1 \text{ mole}}{\text{g-formula-mass}} \right) \quad \left(\frac{\text{g-formula-mass}}{1 \text{ mole}} \right)$$

$$\left(\frac{1 \text{ mole}}{22.4 \text{ L}} \right) \quad \left(\frac{22.4 \text{ L}}{1 \text{ mole}} \right)$$

Mole-Particle Conversions

1. How many moles of magnesium is 3.01×10^{22} atoms of magnesium?

$$3.01 \times 10^{22} \text{ atoms} \left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ atoms}} \right) = 5 \times 10^{-2} \text{ moles}$$

2. How many molecules are there in 4.00 moles of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$?

$$4.00 \text{ moles} \left(\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mole}} \right) = 2.41 \times 10^{24} \text{ molecules}$$

3. How many moles are 1.20×10^{25} atoms of phosphorous?

$$1.20 \times 10^{25} \text{ atoms} \left(\frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}} \right) = 19.9 \text{ moles}$$

4. How many atoms are in 0.750 moles of zinc?

$$0.750 \text{ mol} \left(\frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}} \right) = 4.52 \times 10^{23} \text{ atoms}$$

5. How many molecules are in 0.400 moles of N_2O_5 ?

$$0.400 \text{ mol} \left(\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \right) = 2.41 \times 10^{23} \text{ molecules}$$

Mole-Mass Conversions

1. How many moles in 28 grams of CO_2 ?

Gram-formula-mass of CO_2

$$\begin{array}{l} 1 \text{ C} = 1 \times 12.01 \text{ g} = 12.01 \text{ g} \\ 2 \text{ O} = 2 \times 16.00 \text{ g} = \underline{32.00 \text{ g}} \\ \hline 64.00 \text{ g/mol} \end{array}$$

$$28 \text{ g CO}_2 \left(\frac{1 \text{ mole}}{44.00 \text{ g}} \right) = 0.64 \text{ moles CO}_2$$

2. What is the mass of 5 moles of Fe_2O_3 ?

Gram-formula-mass Fe_2O_3

$$\begin{array}{l} 2 \text{ Fe} = 2 \times 55.6 \text{ g} = 111.2 \text{ g} \\ 3 \text{ O} = 3 \times 16.0 \text{ g} = \underline{48.0 \text{ g}} \\ \hline 159.2 \text{ g/mol} \end{array}$$

$$5 \text{ moles Fe}_2\text{O}_3 \left(\frac{159.2 \text{ g}}{1 \text{ mole}} \right) = 800 \text{ grams Fe}_2\text{O}_3$$

3. Find the number of moles of argon in 452 g of argon.

$$452 \text{ g Ar} \left(\frac{1 \text{ mol}}{40 \text{ g}} \right) = 11.3 \text{ moles Argon}$$

4. Find the grams in 1.26×10^{-4} mol of $\text{HC}_2\text{H}_3\text{O}_2$.

$$1.26 \times 10^{-4} \text{ mol} \left(\frac{60 \text{ g}}{1 \text{ mol}} \right) = 7.56 \times 10^{-3} \text{ g}$$

5. Find the mass in 2.6 mol of lithium bromide.

$$2.6 \text{ mol} \left(\frac{86.8 \text{ g}}{1 \text{ mol}} \right) = 225.68 \text{ or } 230 \text{ g}$$

SF

Mole-Volume Conversions

1. Determine the volume, in liters, occupied by 0.030 moles of a gas at STP.

$$0.030 \text{ mol} \left(\frac{22.4 \text{ L}}{1 \text{ mole}} \right) = 0.67 \text{ L}$$

2. How many moles of argon atoms are present in 11.2 L of argon gas at STP?

$$11.2 \text{ L} \left(\frac{1 \text{ mole}}{22.4 \text{ L}} \right) = 0.500 \text{ moles}$$

3. What is the volume of 0.05 mol of neon gas at STP?

$$0.05 \text{ mol} \left(\frac{22.4 \text{ L}}{1 \text{ mol}} \right) = 1.12 \text{ L}$$

4. What is the volume of 1.2 moles of water vapor at STP?

$$1.2 \text{ mol} \left(\frac{22.4 \text{ L}}{1 \text{ mol}} \right) = 26.9 \text{ L}$$

Mixed Mole Conversions

Given unit → Moles → Desired unit

1. How many oxygen molecules are in 3.36 L of oxygen gas at STP?

$$3.36 \text{ L} \left(\frac{1 \text{ mole}}{22.4 \text{ L}} \right) \left(\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mole}} \right) = 9.03 \times 10^{22} \text{ molecules}$$

2. Find the mass in grams of 2.00×10^{23} molecules of F_2 . 12.624 g

Gram-formula-mass $2 \text{ F} = 2 \times 19 \text{ g} = 38 \text{ g/mol}$

$$2.00 \times 10^{23} \text{ molecules} \left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ particles}} \right) \left(\frac{38 \text{ g}}{1 \text{ mole}} \right) = 12.6 \text{ g}$$

3. Determine the volume in liters occupied by 14 g of nitrogen gas at STP.

Ans. 11.2 L

$$14g N_2 \left(\frac{1 \text{ mol}}{28g} \right) \left(\frac{22.4L}{1 \text{ mol}} \right) = 11.2 L$$

4. Find the mass, in grams, of 1.00×10^{23} molecules of N_2 .

Ans. 4.65 g

$$1.00 \times 10^{23} \text{ molecules} \left(\frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molecules}} \right) \left(\frac{28g}{1 \text{ mol}} \right) = 4.65g$$

5. How many particles are there in 1.43 g of a molecular compound with a gram molecular mass of 233 g?

Ans. 3.69×10^{21}

$$1.43g \left(\frac{1 \text{ mol}}{233g} \right) \left(\frac{6.02 \times 10^{23}}{1 \text{ mol}} \right) = 3.69 \times 10^{21} \text{ particles.}$$

6. Aspartame is an artificial sweetener that is 160 times sweeter than sucrose (table sugar) when dissolved in water. It is marketed by G.D. Searle as *Nutra Sweet*. The molecular formula of aspartame is $C_{14}H_{18}N_2O_5$.

a) Calculate the gram-formula-mass of aspartame.

294 g/mol

$$14(12) + 18(1) + 2(14) + 5(16) = 294g$$

b) How many moles of molecules are in 10 g of aspartame?

3.4×10^{-2} moles

$$10g \left(\frac{1 \text{ mol}}{294g} \right) = 3.4 \times 10^{-2} \text{ moles}$$

c) What is the mass in grams of 1.56 moles of aspartame?

458.64 grams

$$1.56 \text{ mol} \left(\frac{294g}{1 \text{ mol}} \right) = 458.64g$$

d) How many molecules are in 5 mg of aspartame?

1.0238×10^{19}

$$5 \text{ mg} \left(\frac{1g}{1000 \text{ mg}} \right) \left(\frac{1 \text{ mol}}{294g} \right) \left(\frac{6.02 \times 10^{23}}{1 \text{ mol}} \right) = 1.0238 \times 10^{19} \text{ molecules}$$

e) How many atoms of nitrogen are in 1.2 grams of aspartame?

4.9143×10^{21}

$$1.2g \left(\frac{1 \text{ mol}}{294g} \right) \left(\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \right) \left(\frac{2 \text{ N atoms}}{1 \text{ molecule}} \right) = 4.9 \times 10^{21} \text{ atoms.}$$

Name: _____

Period: _____

Mixed Mole Problems Worksheet

Directions: Solve the following problems. Be sure to show all your work

1. Find the number of moles if there are 7.63×10^{24} molecules of a substance.

$$7.63 \times 10^{24} \left(\frac{1 \text{ mol}}{6.02 \times 10^{23}} \right) = 12.7 \text{ moles}$$

2. How many moles of CaCO_3 are there in 2.00 kg of CaCO_3 ?

$$2.00 \text{ kg} \left(\frac{1000 \text{ g}}{1 \text{ kg}} \right) \left(\frac{1 \text{ mol}}{100.1 \text{ g}} \right) = 20.0 \text{ moles}$$

3. What is the mass of 8.42 moles of $(\text{NH}_4)_2\text{S}$?

$$8.42 \text{ mol} \left(\frac{68.1 \text{ g}}{1 \text{ mol}} \right) = 573 \text{ g}$$

4. Find the number of carbon atoms in 18.5 g of CH_3OH (methanol).

$$18.5 \text{ g} \left(\frac{1 \text{ mol}}{32 \text{ g}} \right) \left(\frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \right) \left(\frac{1 \text{ atom}}{1 \text{ molecule}} \right) = 3.48 \times 10^{23} \text{ atoms.}$$

5. If one litre of a gas at STP has a mass of 3.17 g, what is the molar mass of this gas? Name the diatomic element that makes up this gas?

$$\frac{3.17 \text{ g}}{\text{L}} \left(\frac{22.4 \text{ L}}{1 \text{ mol}} \right) = 71 \text{ g/mol}$$

6. What volume at STP would 11.50 g of oxygen gas occupy?

$$11.50 \text{ g} \left(\frac{1 \text{ mol}}{32 \text{ g}} \right) \left(\frac{22.4 \text{ L}}{1 \text{ mol}} \right) = 8.05 \text{ L}$$

Name: _____

Period: _____

7. What is the mass of 33.2 L of SO_2 gas at STP?

$$33.2\text{L} \left(\frac{1\text{mol}}{22.4\text{L}} \right) \left(\frac{64.1\text{g}}{1\text{mol}} \right) = 95.0\text{g}$$

8. Based on the data from the periodic table, calculate the density of Fluorine gas at STP in g/L.

$$\frac{38\text{ g}}{\text{mol}} \left(\frac{1\text{mol}}{22.4\text{L}} \right) = 1.7\text{g/L}$$

9. Calculate the molar mass of a gas at STP, if 360.0 mL of this gas has a mass of 0.680 g

$$\frac{0.680\text{g}}{360.0\text{mL}} \left(\frac{1000\text{mL}}{1\text{L}} \right) \left(\frac{22.4\text{L}}{1\text{mol}} \right) = 42.3\text{g/mol}$$

10. Methane has the formula CH_4 . Calculate the mass of 2.75 L of this gas at STP.

$$2.75\text{L} \left(\frac{1\text{mol}}{22.4\text{L}} \right) \left(\frac{18\text{g}}{1\text{mol}} \right) = 2.21\text{g}$$

11. What is the mass of 5580.0 mL of nitrogen gas at STP?

$$5580.0\text{mL} \left(\frac{1\text{L}}{1000\text{mL}} \right) \left(\frac{1\text{mol}}{22.4\text{L}} \right) \left(\frac{28\text{g}}{1\text{mol}} \right) = 6.975\text{g}$$

12. How many atoms of bromine are there in 175.0 mL of bromine gas at STP?

$$175.0\text{mL} \left(\frac{1\text{L}}{1000\text{mL}} \right) \left(\frac{1\text{mol}}{22.4\text{L}} \right) \left(\frac{6.02 \times 10^{23} \text{ molecules}}{1\text{mol}} \right) \left(\frac{2\text{ Br atoms}}{1\text{ molecule}} \right) = 9.406 \times 10^{21} \text{ atoms}$$

13. How many molecules of CO_2 are there in 2.57 L of this gas at STP.

$$2.57\text{L} \left(\frac{1\text{mol}}{22.4\text{L}} \right) \left(\frac{6.02 \times 10^{23} \text{ molecules}}{1\text{mol}} \right) = 6.91 \times 10^{22} \text{ molecules}$$

Percent Composition Worksheet

- 1) What is the percent composition of nitrogen in AgNO_3 ?

$$\frac{14g}{102} \times 100 = 14\%$$

- 2) What is the percent composition of carbon in $\text{C}_2\text{H}_5\text{O}$?

$$\frac{2(12g)}{2(12g) + 5(1g) + 1(16g)} \times 100 = 53\%$$

- 3) What is the percent composition of hydrogen in H_2SO_4 ?

$$\frac{2(1g)}{2(1g) + 1(32.1g) + 4(16g)} \times 100 = 2\%$$

- 4) What is the percent composition of sulfur in sulfur hexafluoride? SF_6

$$\frac{32.1g}{1(32.1g) + 6(19g)} \times 100 = 22\%$$

- 5) What is the percent composition of iron in iron (II) sulfide? FeS

$$\frac{1(55.8g)}{1(55.8g) + 1(32.1)} \times 100 = 63\%$$

- 6) What is the percent composition of lithium in lithium phosphate? Li_3PO_4

$$\frac{3(6.9g)}{3(6.9g) + 1(31g) + 4(16g)} \times 100 = 0.05\%$$

Name _____

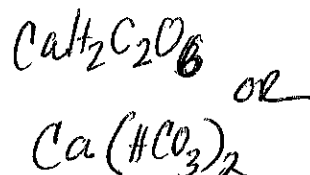
Date _____ Pd _____

Empirical Formulas Worksheet, #1

Directions: Find the empirical formula and name for each of the following.

1. A compound is 24.7% Calcium, 1.2% Hydrogen, 14.8% Carbon, and 59.3% Oxygen. Write the empirical formula and name the compound.

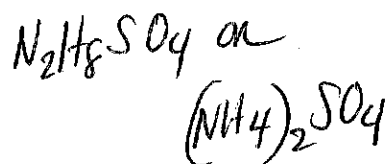
$$\begin{aligned} \text{Calcium } 24.7\% & \left(\frac{1 \text{ mol}}{40.1 \text{ g}} \right) = \frac{0.6159}{0.6159} = \sim 1 \\ \text{Hydrogen } 1.2\% & \left(\frac{1 \text{ mol}}{1 \text{ g}} \right) = \frac{1.2000}{1.2000} = \sim 2 \\ \text{Carbon } 14.8\% & \left(\frac{1 \text{ mol}}{12 \text{ g}} \right) = \frac{1.2333}{1.2333} = \sim 2 \\ \text{Oxygen } 59.3\% & \left(\frac{1 \text{ mol}}{16 \text{ g}} \right) = \frac{3.70625}{3.70625} = 1 \end{aligned}$$



Calcium bicarbonate

2. A compound is 21.20% Nitrogen, 6.06% Hydrogen, 24.30% Sulfur, and 48.45% Oxygen. Write the empirical formula and name the compound.

$$\begin{aligned} 21.20\% \text{ N} & \left(\frac{1 \text{ mol}}{14 \text{ g}} \right) = \frac{1.5143}{0.7570} = 2 \\ 6.06\% \text{ H} & \left(\frac{1 \text{ mol}}{1 \text{ g}} \right) = \frac{6.060}{0.7570} = 8 \\ 24.30\% \text{ S} & \left(\frac{1 \text{ mol}}{32.1 \text{ g}} \right) = \frac{0.7570}{0.7570} = 1 \\ 48.45\% \text{ O} & \left(\frac{1 \text{ mol}}{16 \text{ g}} \right) = \frac{3.028}{0.7570} = 4 \end{aligned}$$



Ammonium sulfate

3. A compound is 44.82% Potassium, 18.39% Sulfur, and 36.79% Oxygen. Write the empirical formula and name the compound.

$$\begin{aligned} 44.82\% \text{ K} & \left(\frac{1 \text{ mol}}{39.1 \text{ g}} \right) = \frac{1.1463}{0.5729} = 2 \\ 18.39\% \text{ S} & \left(\frac{1 \text{ mol}}{32.1 \text{ g}} \right) = \frac{0.5729}{0.5729} = 1 \\ 36.79\% \text{ O} & \left(\frac{1 \text{ mol}}{16 \text{ g}} \right) = \frac{2.2994}{0.5729} = 4 \end{aligned}$$



Potassium sulfate

4. A compound is 52.0% Zinc, 9.6% Carbon, and 38.4% Oxygen. Calculate the empirical formula of the compound.

$$\begin{aligned}
 52.0 \text{ g Zn} \left(\frac{1 \text{ mol}}{65.4} \right) &= \frac{0.7951}{0.7951} = 1 \\
 9.6 \text{ g C} \left(\frac{1 \text{ mol}}{12 \text{ g}} \right) &= \frac{0.80}{0.7951} = 1 \\
 38.4 \text{ g O} \left(\frac{1 \text{ mol}}{16 \text{ g}} \right) &= \frac{2.4}{0.7951} = 3
 \end{aligned}$$

ZnCO_3

5. A compound is 92.2% Carbon and 7.76% Hydrogen. The formula mass of the compound is 78.1 g. Calculate the empirical formula and molecular formula of the compound.

$$\begin{aligned}
 92.2 \text{ g C} \left(\frac{1 \text{ mol}}{12 \text{ g}} \right) &= \frac{7.6833}{7.6833} = 1 \quad \text{CH} \quad \frac{78.1 \text{ g}}{13} = 6 \\
 7.76 \text{ g H} \left(\frac{1 \text{ mol}}{1 \text{ g}} \right) &= \frac{7.76 \text{ mol H}}{7.6833} = 1
 \end{aligned}$$

C_6H_6

6. A compound is 43.7% Phosphorus and 56.3% Oxygen. The formula mass of the compound is 284 g. Calculate the empirical formula and molecular formula of the compound.

$$\begin{aligned}
 43.7 \text{ g P} \left(\frac{1 \text{ mol}}{31 \text{ g}} \right) &= \frac{1.4097}{1.4079} = 1 \times 2 \\
 56.3 \text{ g O} \left(\frac{1 \text{ mol}}{16 \text{ g}} \right) &= \frac{3.5188}{1.4079} = 2.5 \times 2
 \end{aligned}$$

P_2O_5

$\frac{284}{142} = 2$

P_4O_{10}

7. In an experiment, it was found that 11.775 g of Sn combined with 3.180 g of O. Write the empirical formula and name the compound that is formed.

$$\begin{aligned}
 11.775 \text{ g Sn} \left(\frac{1 \text{ mol}}{118.} \right) &= \frac{0.09979}{0.09979} = 1 \\
 3.180 \text{ g O} \left(\frac{1 \text{ mol}}{16 \text{ g}} \right) &= \frac{0.19875}{0.09979} = 2
 \end{aligned}$$

SnO_2

Tin II Oxide

8. A compound contains 21.6% Na, 33.3% Cl, and 45.1% O. Write the empirical formula and name the compound that is formed.

$$21.6g \text{ Na} \left(\frac{1 \text{ mol}}{23g} \right) = \frac{0.9391}{0.9380} = 1$$

$$33.3g \text{ Cl} \left(\frac{1 \text{ mol}}{35.5g} \right) = \frac{0.9380}{0.9380} = 1$$

$$45.1g \text{ O} \left(\frac{1 \text{ mol}}{16g} \right) = \frac{2.8188}{0.9380} = 3$$



Sodium Chlorate

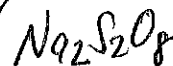
9. A compound is 19.3% Na, 26.9% S, and 53.8% O. Its formula mass is 238 g. What is its molecular formula?

$$19.3g \text{ Na} \left(\frac{1 \text{ mol}}{23g} \right) = \frac{0.8391}{0.8380} = 1$$

$$26.9g \text{ S} \left(\frac{1 \text{ mol}}{32.1g} \right) = \frac{0.8380}{0.8380} = 1$$

$$53.8g \text{ O} \left(\frac{1 \text{ mol}}{16g} \right) = \frac{3.3625}{0.8380} = 4$$

$$\frac{238}{119} = 2$$



Sodium Sulfate

10. An experiment uses a catalyst that is 23.3% Co, 25.3% Mo, and 51.4% Cl. What is the empirical formula of the compound?

$$23.3g \text{ Co} \left(\frac{1 \text{ mol}}{58.9g} \right) = \frac{0.3956}{0.2637} = 1.5 \times 2$$

$$25.3g \text{ Mo} \left(\frac{1 \text{ mol}}{95.94g} \right) = \frac{0.2637}{0.2637} = 1 \times 2$$

$$51.4g \text{ Cl} \left(\frac{1 \text{ mol}}{35.5g} \right) = \frac{1.4479}{0.2637} = 5.5 \times 2$$



1. Benzene, a non-polar solvent used for many applications in industry, and a major component in many organic compounds has the following percent composition:

$$C = 92.3\%$$

$$H = 7.8\%$$

$$92.3g C \left(\frac{1 \text{ mol}}{12g} \right) = \frac{7.6917}{7.6917}$$

$$7.8g H \left(\frac{1 \text{ mol}}{1g} \right) = \frac{7.8}{7.6917} \text{ mol H}$$

a. Find Benzene's empirical formula.



b. Find the Molecular formula of benzene if the entire formula mass is 78.12 g/mol

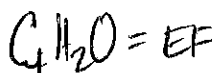
$$\frac{78.12}{12.01} = 6$$



2. An unknown sugar is found to have a formula mass of 180.18 g/mol. The sugar contains:

40.0 % C, 6.7 % H and 53.3 % O.

a. Find the empirical and molecular formula of this sugar. b. What's its name?



$$\frac{180}{30} = 6$$

$$40g C \left(\frac{1 \text{ mol}}{12g} \right) = \frac{3.33}{3.33}$$

$$6.7g H \left(\frac{1 \text{ mol}}{1g} \right) = \frac{6.7}{3.33}$$

$$53.3g O \left(\frac{1 \text{ mol}}{16g} \right) = \frac{3.33}{3.33}$$

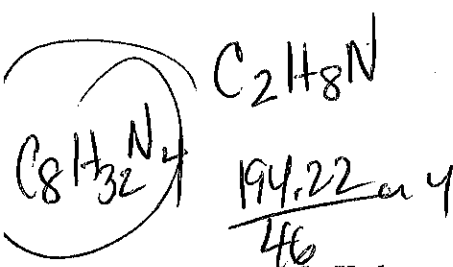
$$\frac{3.33}{3.33}$$

3. Tryptophan – the chemical in turkey that is believed to make you sleepy – has the empirical formula $C_{11}H_{12}N_2O_2$.

Find the molecular formula if the formula mass is 204.25 g/mol.

$$\frac{204.25}{204} = 1 \quad \text{Empirical and molecular are the same.}$$

4. Caffeine is made of 49.48 % C, 5.19% H, 16.48% O and 28.8% N. Find the molecular mass of Caffeine if its overall molecular mass is 194.22 g/mol



$$49.48g C \left(\frac{1 \text{ mol}}{12g} \right) = \frac{4.123}{2.057}$$

$$16.48g O \left(\frac{1 \text{ mol}}{16g} \right) = \frac{1.03}{2.057}$$

$$28.8g N \left(\frac{1 \text{ mol}}{14g} \right) = \frac{2.057}{2.057}$$

5. Hydrogen peroxide is 5.93 % H and 94.07 % O. Find the formula of hydrogen peroxide given it has an overall formula mass of 34 g/mol.

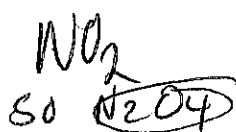
$$HO = 17$$

$$5.93g H \left(\frac{1 \text{ mol}}{1g} \right) = \frac{5.93}{5.879} = 1$$

$$94.07g O \left(\frac{1 \text{ mol}}{16g} \right) = \frac{5.879}{5.879} = 1$$

$$34/17 = 2 \quad \text{So } H_2O_2$$

6. A strong oxidizing agent and rocket propellant has a % composition of 30.43% N and 69.57 % O. Find the molecular formula if its formula mass is 92.0 g/mol.



$$\frac{92}{46} = 2$$

$$30.43g N \left(\frac{1 \text{ mol}}{14g} \right) = \frac{2.174}{2.174} = 1$$

$$69.57g O \left(\frac{1 \text{ mol}}{16g} \right) = \frac{4.348}{2.174} = 2$$